Energy Research for a Fossil Fuel Free Future

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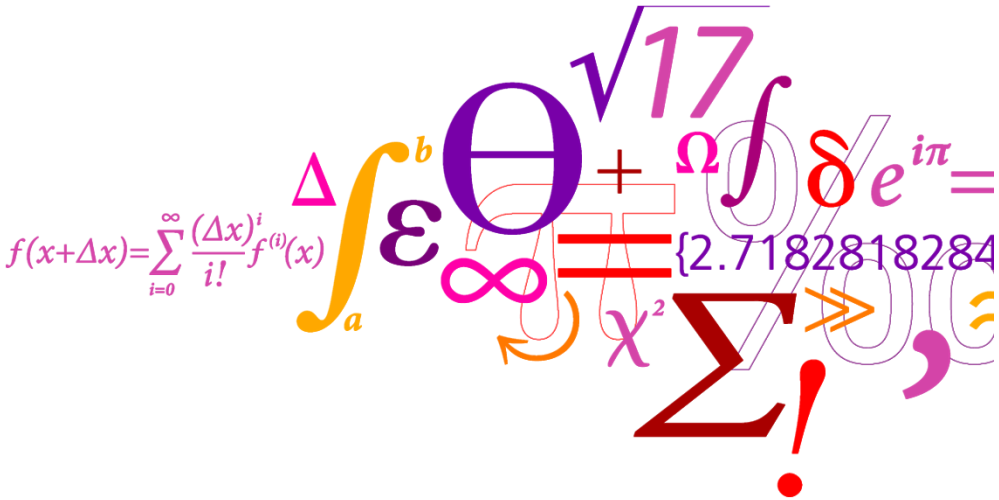


DTU Management Engineering
Department of Management Engineering

Research

- "Research holding the torch of knowledge" from 1896
- Basrelief sculpture made by Olin Levi Warner
- Library of Congress, Thomas Jefferson building, Washington D.C.

- Old French "Recercher" which means " to seek"
- Danish "forske" comes from old German and means "to ask"

The Steam Engine was first time invented by Heron of Alexandria in the first century

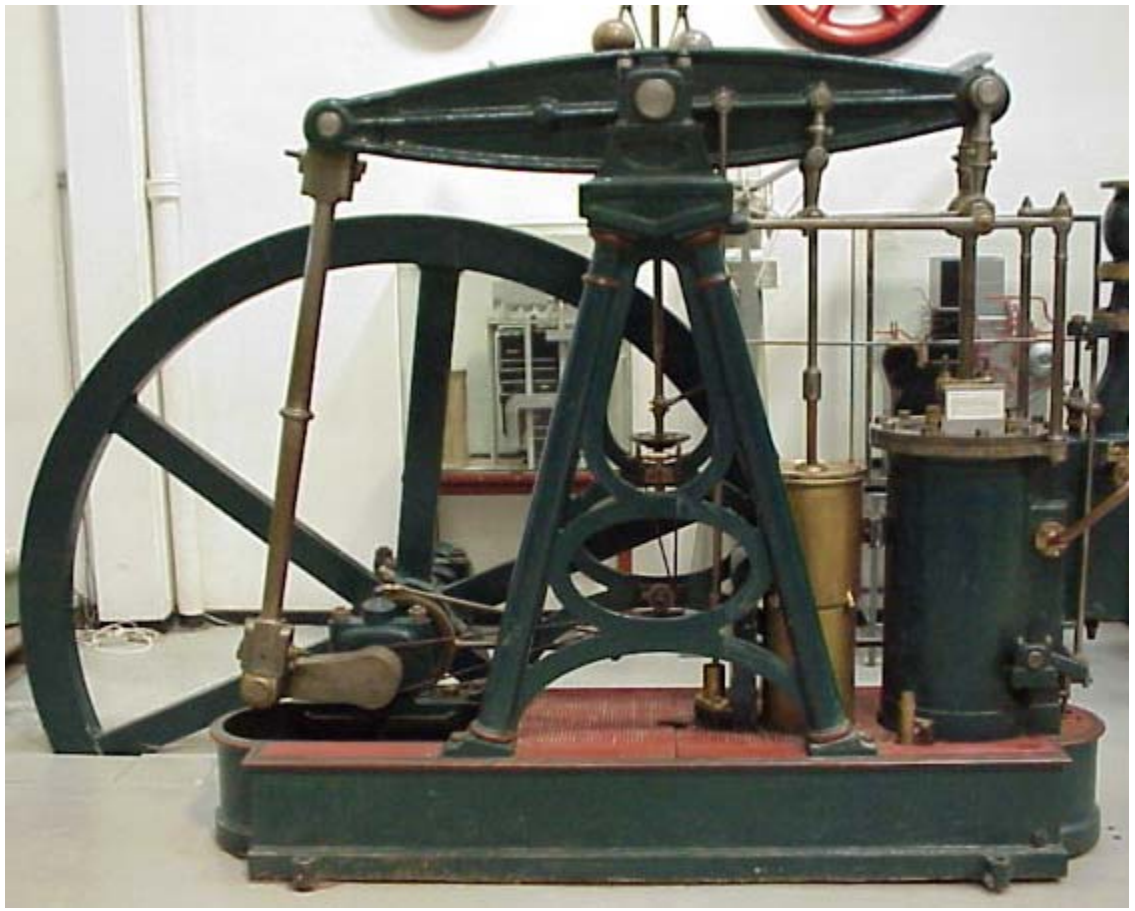
- Was not taken into use at that time
- Manpower was way too cheap (slaves)
- Mass production of goods was not on the agenda

Research:

- **We seek and find solutions**
  - New ideas might be forgotten again
- **Re-search of forgotten ideas**
- **Improvements and Refinements**

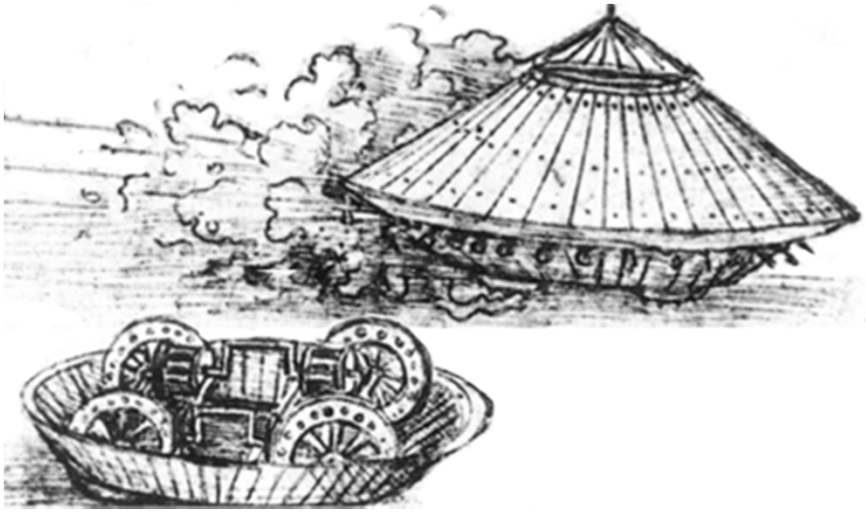
The Steam Engine

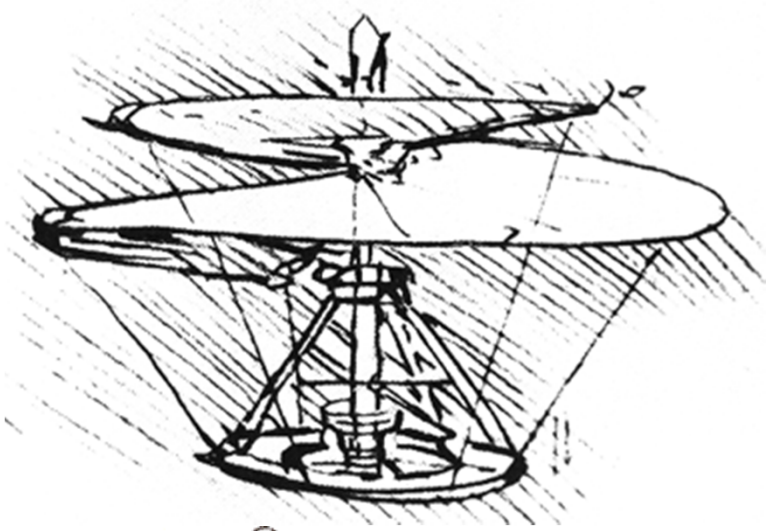
- Re-searched by Thomas Savery in 1698
- Improved among others by James Watt
- One of the drivers of the industrial revolution

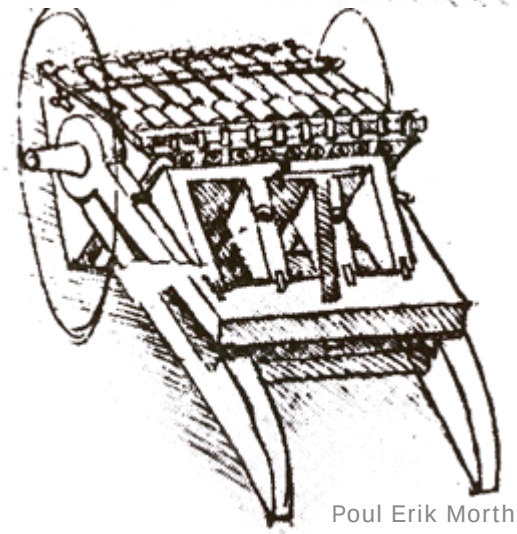


In the 15th Century Leonardo da Vinci had a number of future technologies on his drawing board

... and presumably he also touch upon the Steam Engine







The Danish Energy Future:

Independence of fossil fuels by 2050

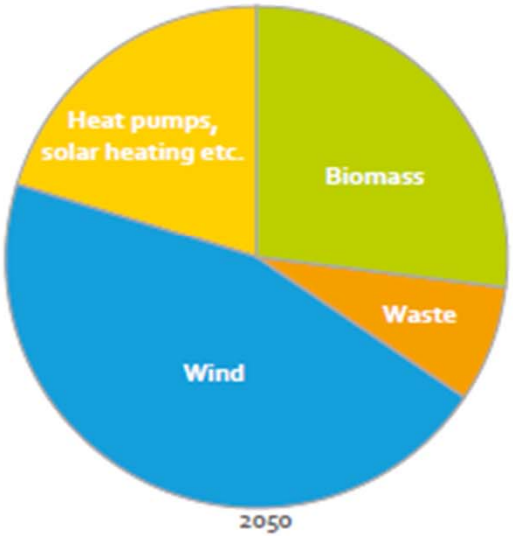
" We can both reduce Danish emissions of greenhouse gasses significantly, and make Denmark independent of fossil fuels. This will require a total conversion of the Danish energy system"

- *Danish Commission on Climate Change Policy*

What do we need to do....

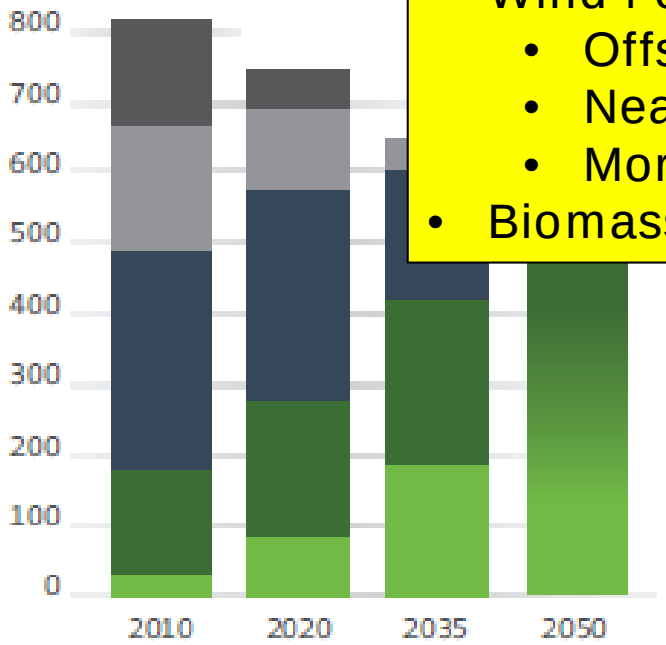
Main Future Trends:

- **An Energy System dominated by electricity**
- **Intermittent sources will have to play a large role**
  - *Wind Power Capacity x 6*
  - *Solar??*
- **The Resource of Biomass is limited**
- **Radical change in trans-port system**
  - *Electric cars, hydrogen, bio-ethanol.....?*



Source: Climate Commission

The Government's Energy Plan



Figur 3.8 Anvendelse af fossile brændsler og VE (PJ)

Until 2020 Parliament has agreed on:

- Energy Savings
- Wind Power
  - Offshore 1000 MW
  - Near Shore turbines 500 MW
  - More Land based 500 MW
- Biomass in central power plants

sh Power
ed by Wind Power

al in Danish Power
es

- **2035:** All heat and power consumption is supplied by renewables
- **2050:** The entire Danish energy consumption is supplied by renewables

This is the Light House for prioritising R&I Energy

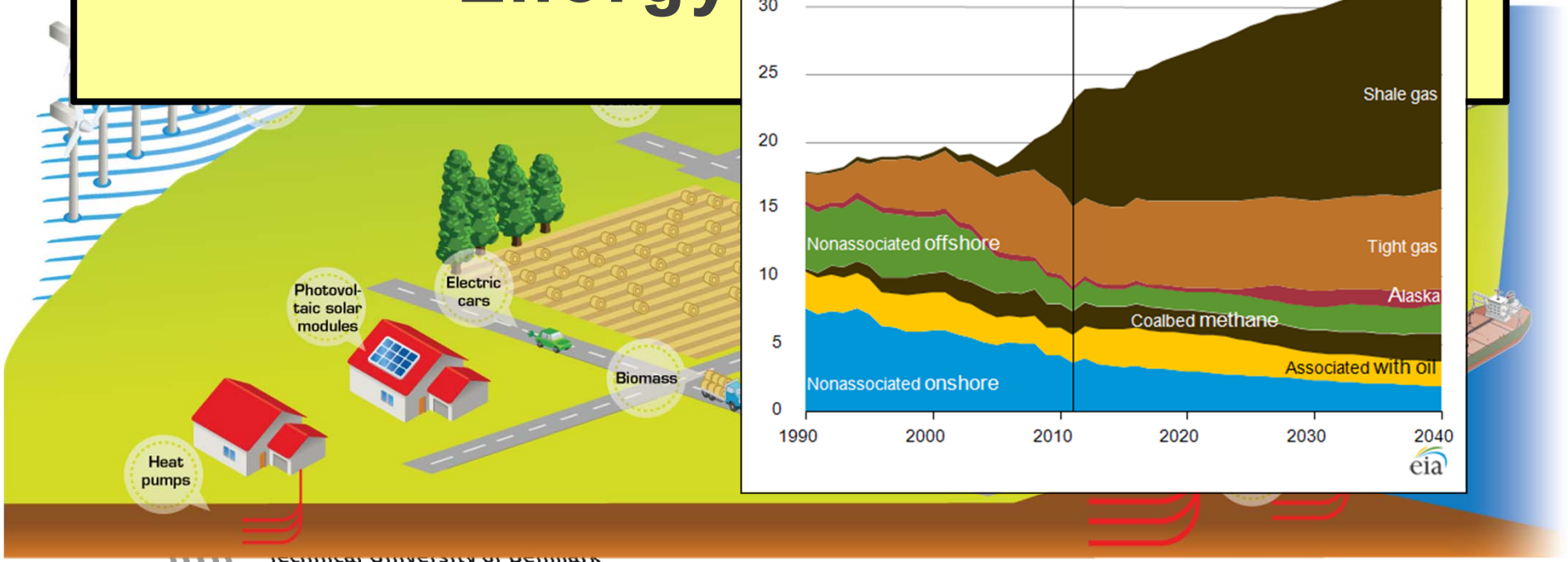
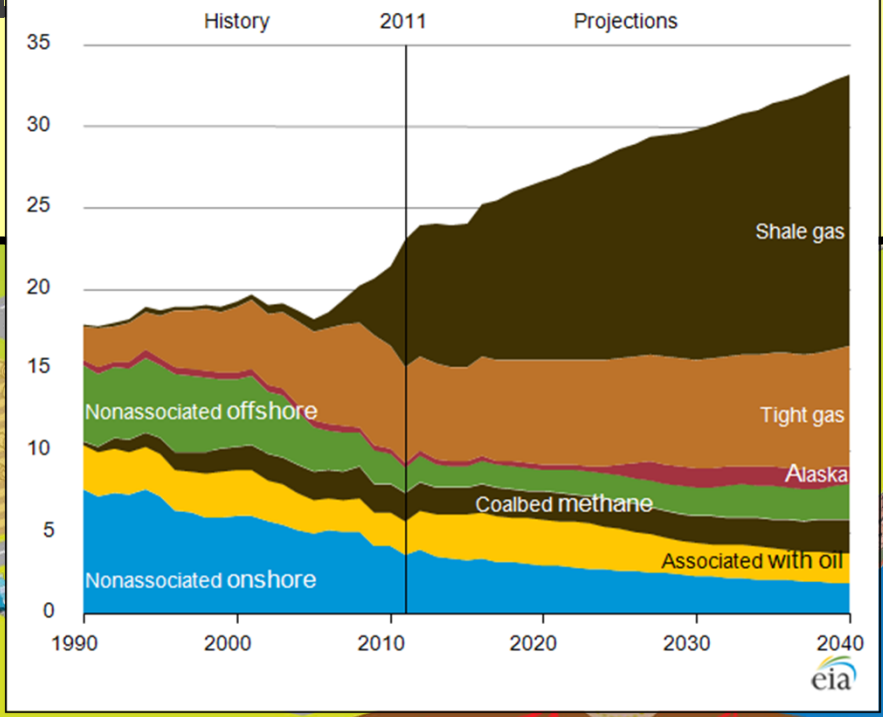
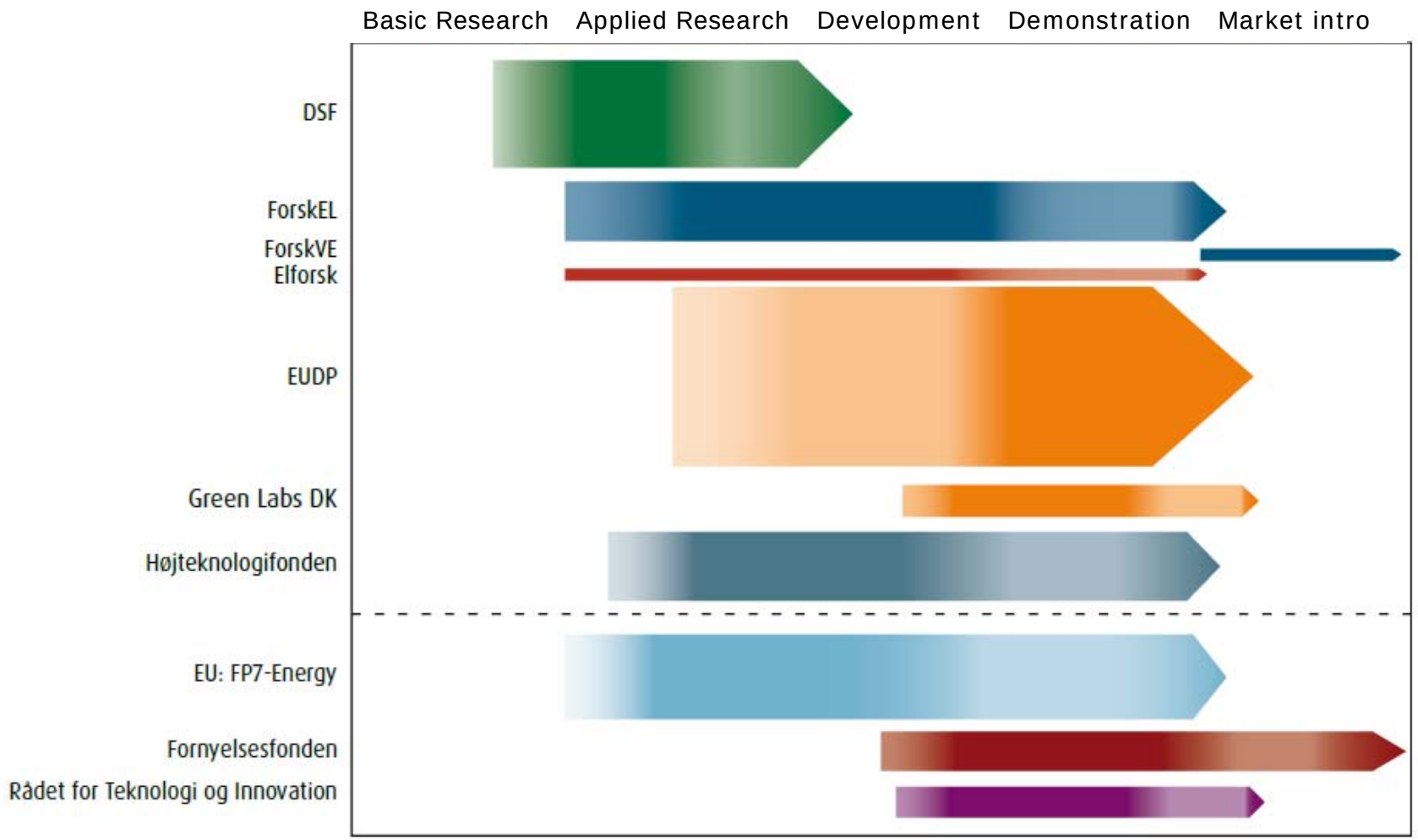


Figure 3. U.S. dry natural gas production by source, 1990-2040

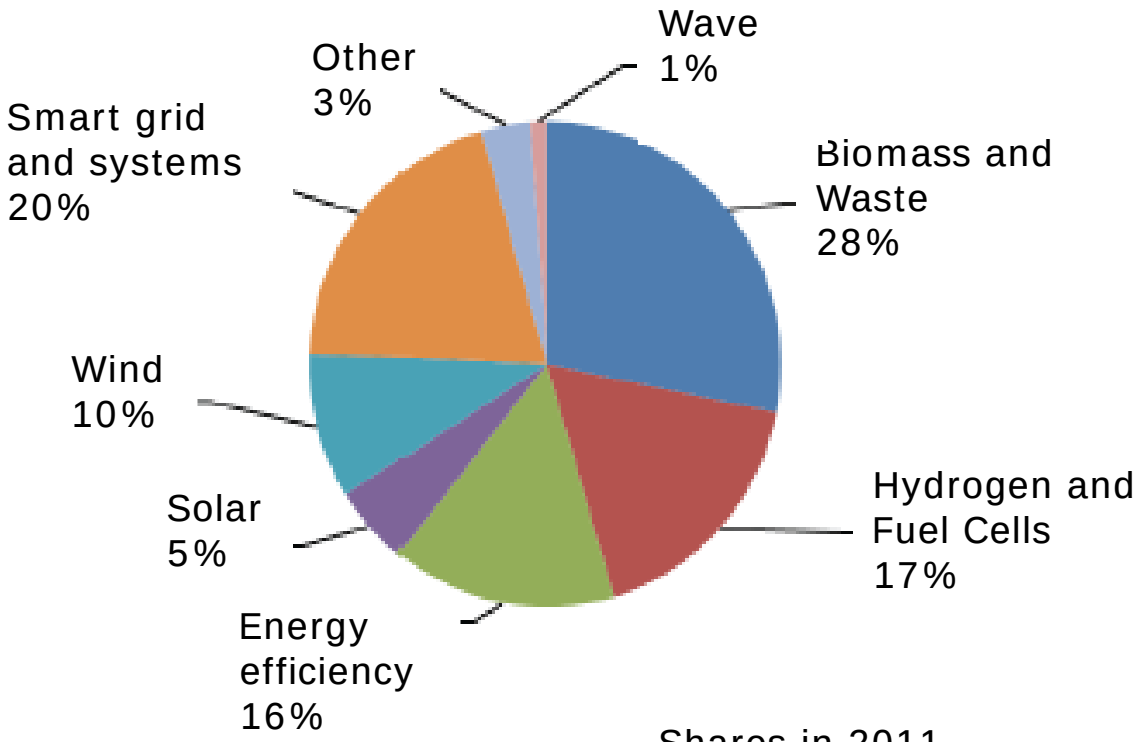
trillion cubic feet



Energy Research Programmes in Denmark

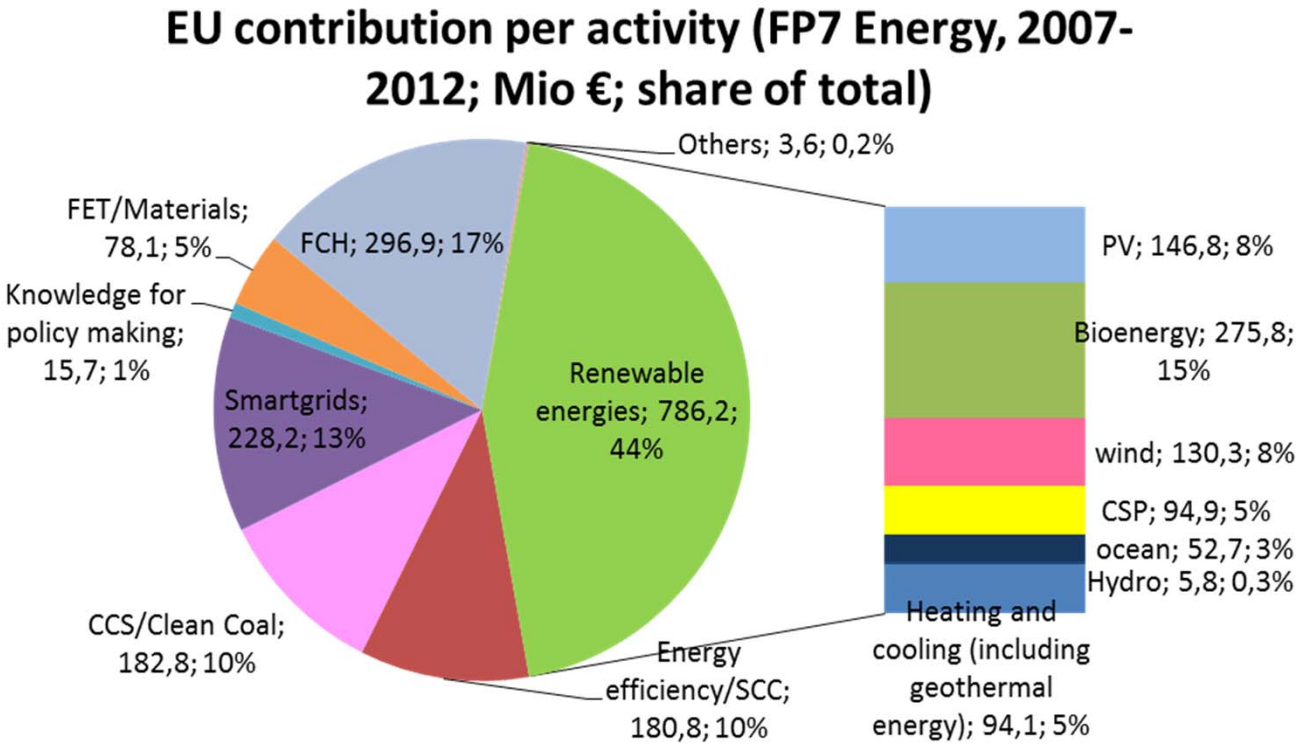


Priorities in Energy Research



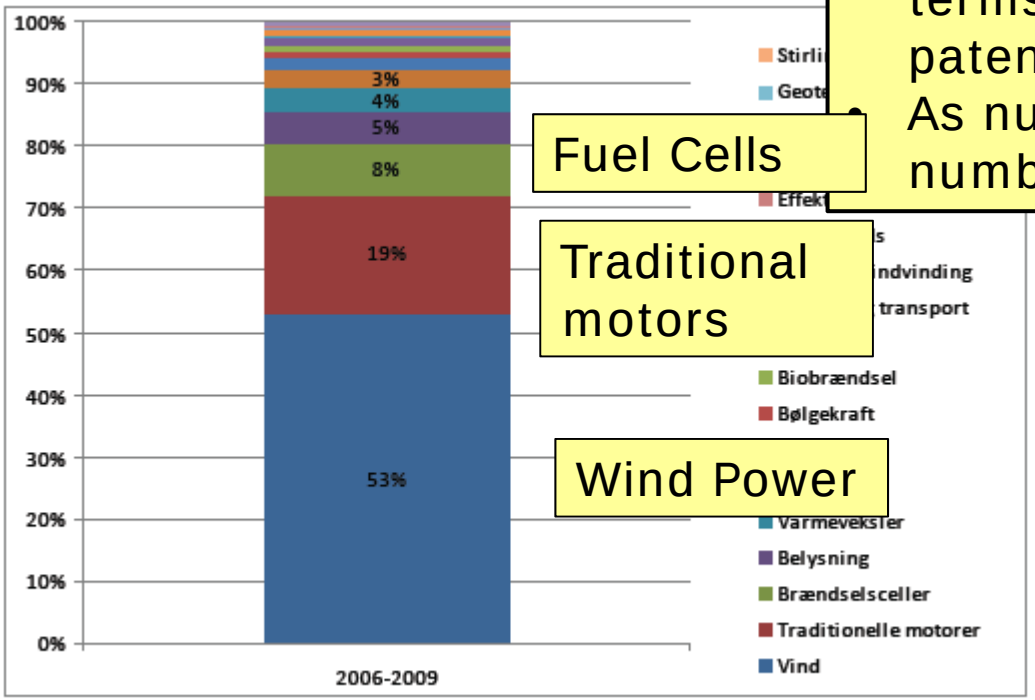
Shares in 2011
Source: www.energiforskning.dk

Energy Research in the EU



What have we achieved in Energy Research?

Patent applications to the European Patent Office



Fuel Cells

Traditional motors

Wind Power

- Denmark ranked as number 14 in the World in terms of number of Energy patent applications
- As number 4 if adjusted for number of inhabitants.

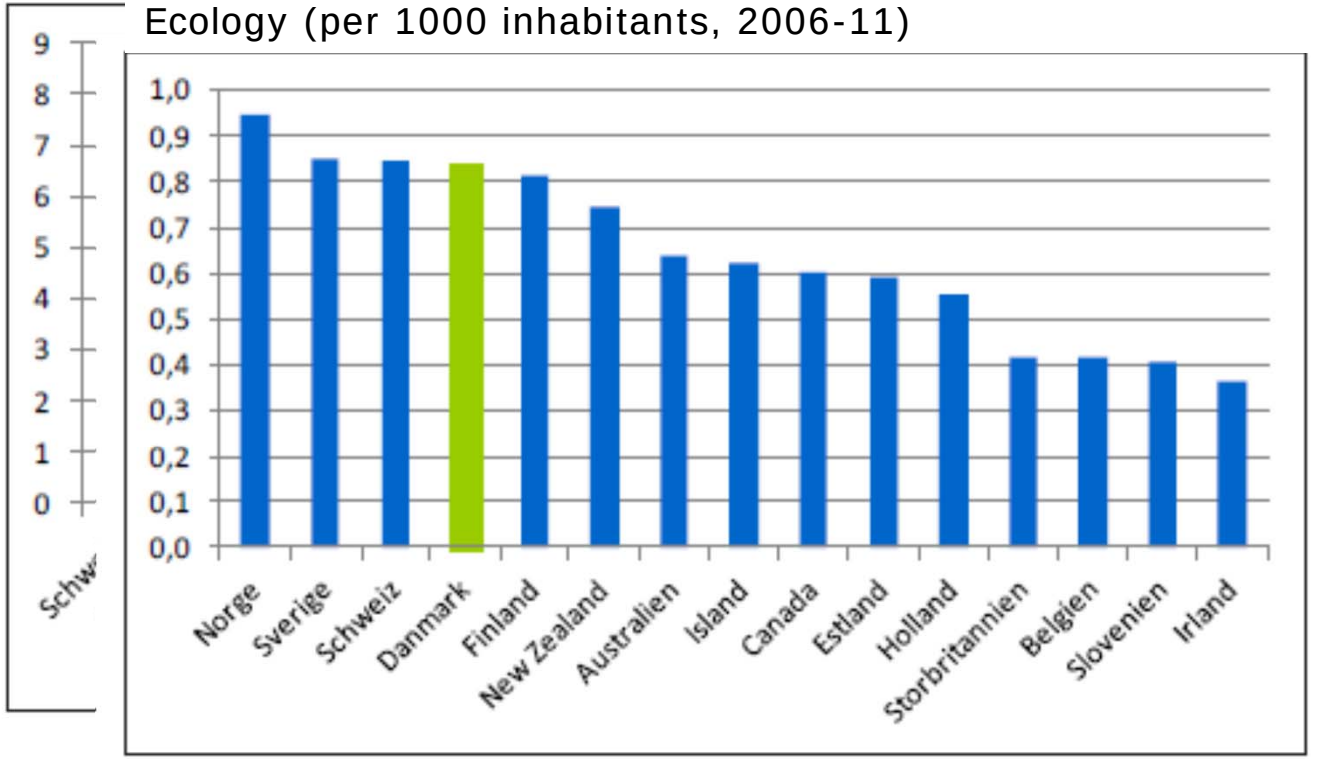
Kilde: Eurostat

Success Stories for Danish Energy Research

- **The applic**
  most fund
  framework
  - 76 mio. €

OECD Top-15 Citations within Energy, Environment and Ecolo

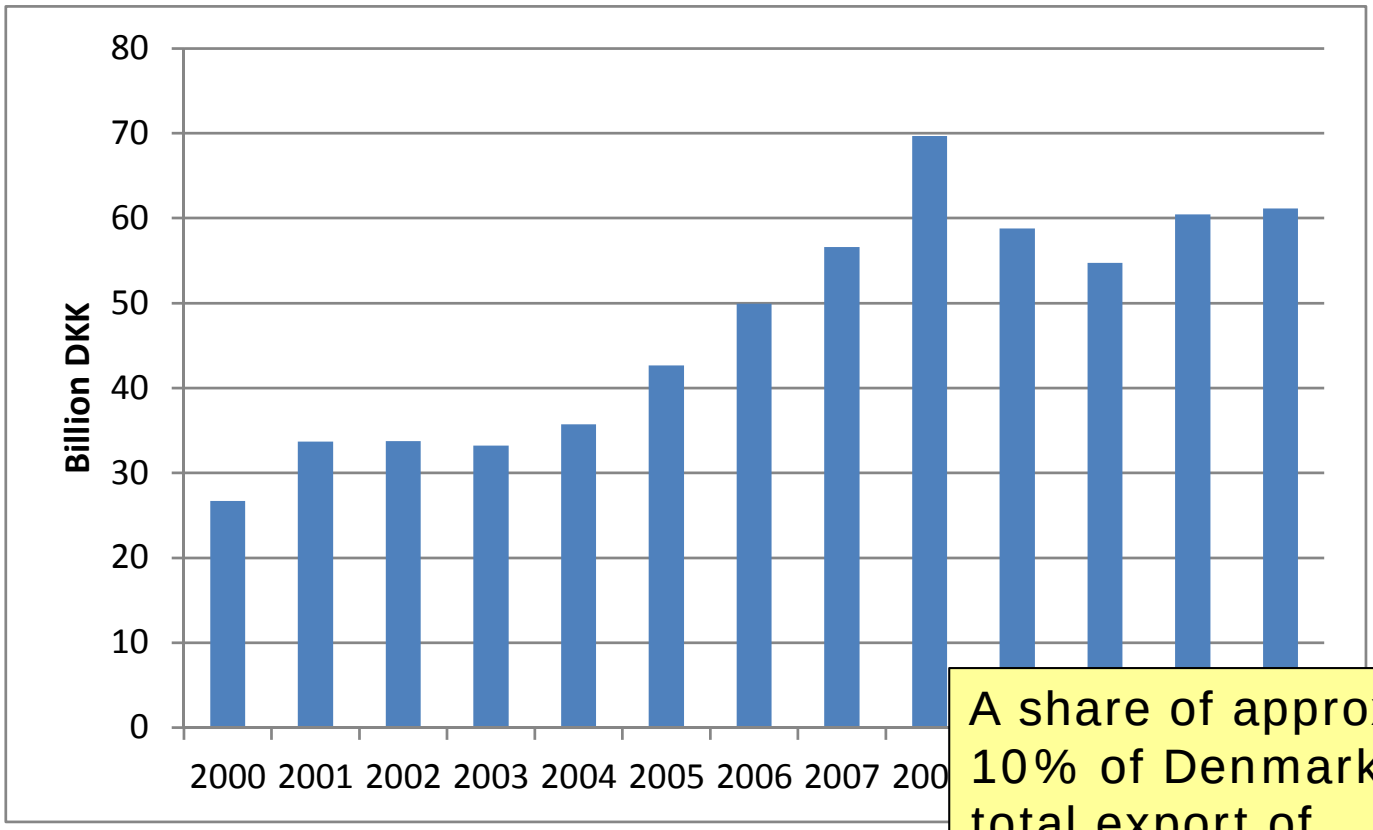
OECD Top-15 Publications within Energy, Environment and Ecology (per 1000 inhabitants, 2006-11)



Kilde: 2010

Kilde: OECD og National Science Indikators 2010. Der er anvendt befolknings tal fra 2010

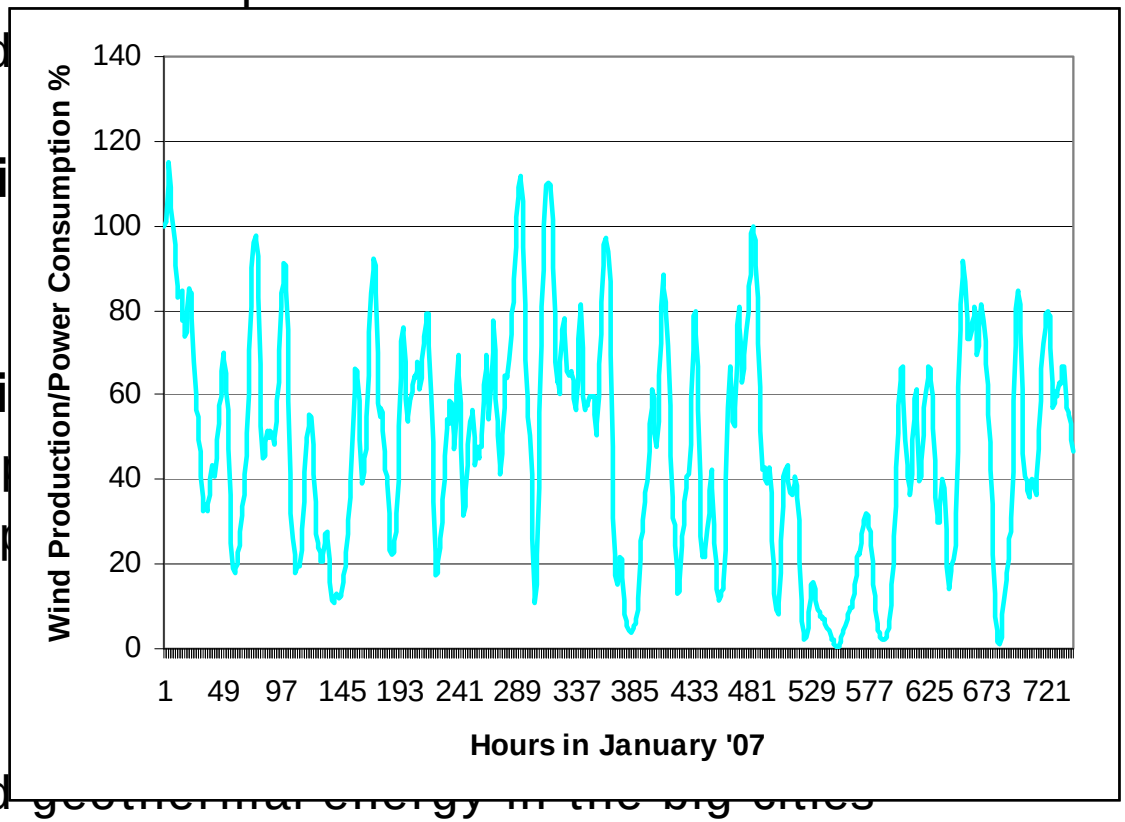
Export of Energy Technologies



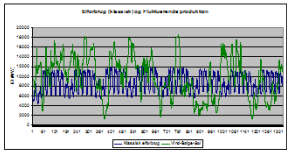
A share of approx. 10% of Denmarks total export of commodities in 2012

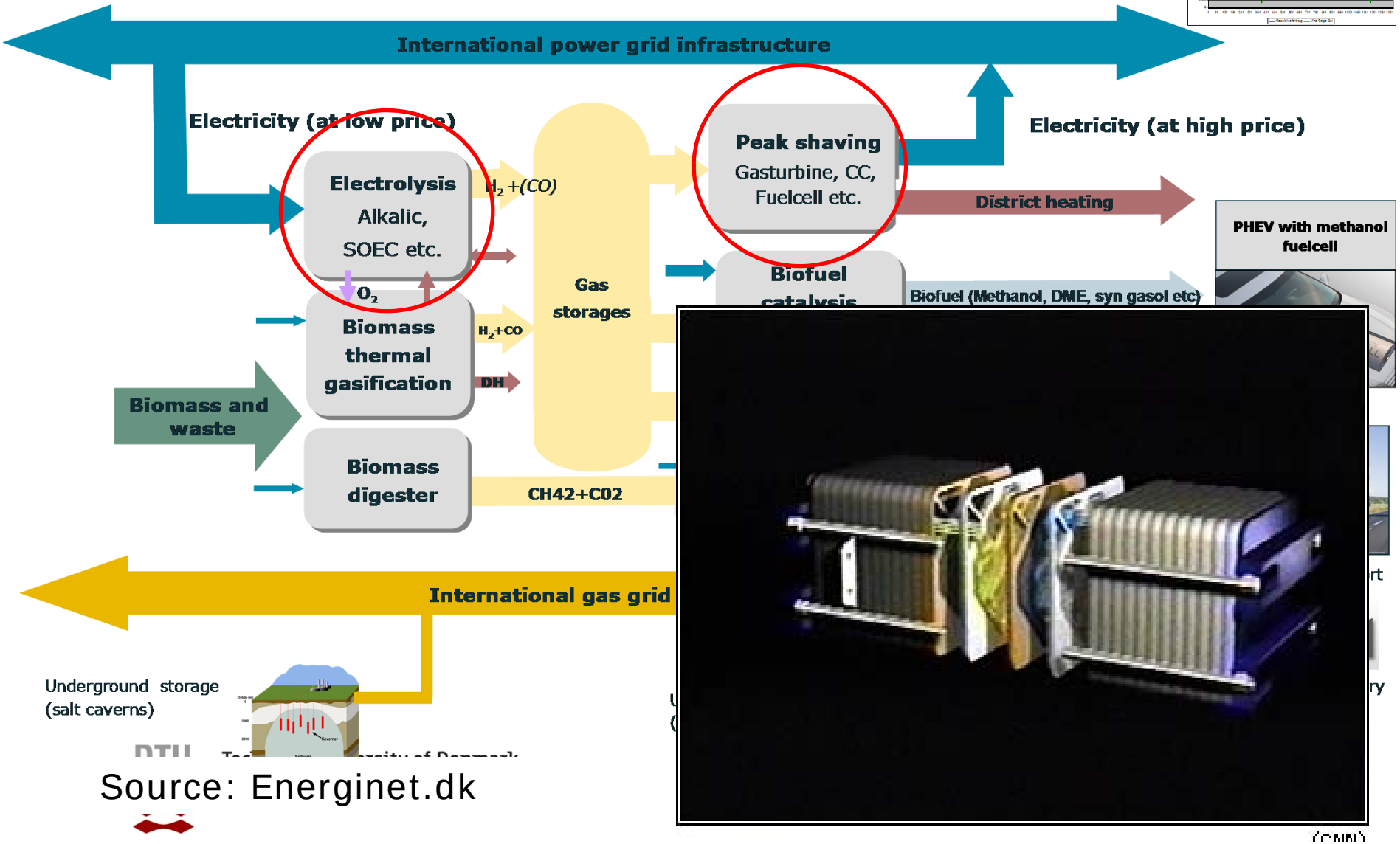
What do we especially need in the transition phase?

- **Need for balancing wind power**
  - Interconnectors can do quite a lot
  - Smart grid and
- **In periods wi**
  - Biomass?
- **Storage facili**
  - Hydrogen is a
  - Natural gas is
    storage
- **New ways of**
  - Heatpunps and
  - Solar heating and heatpumps for decentralised use



Integration of electricity, heat, gas and fuel-production

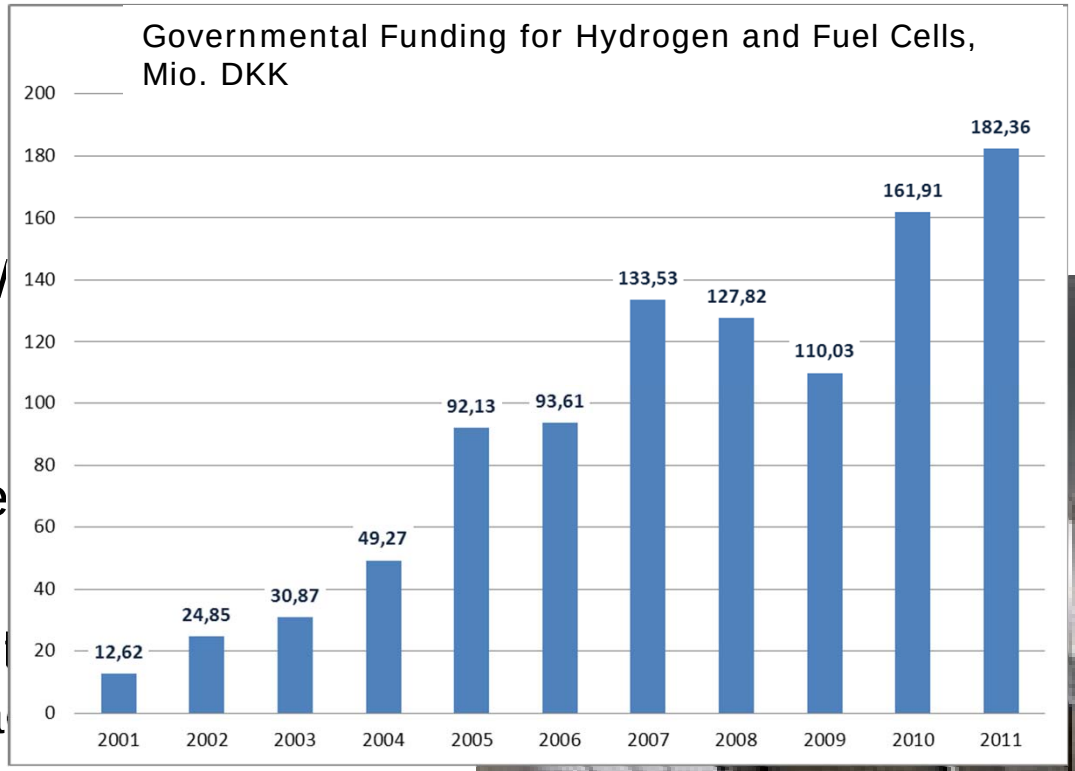




Source: Energinet.dk

Fuel Cell

- Invented by W
  1839
- … but not take
- Came back in
  relation to spa
- Strong research development in the 80s and especially 90s



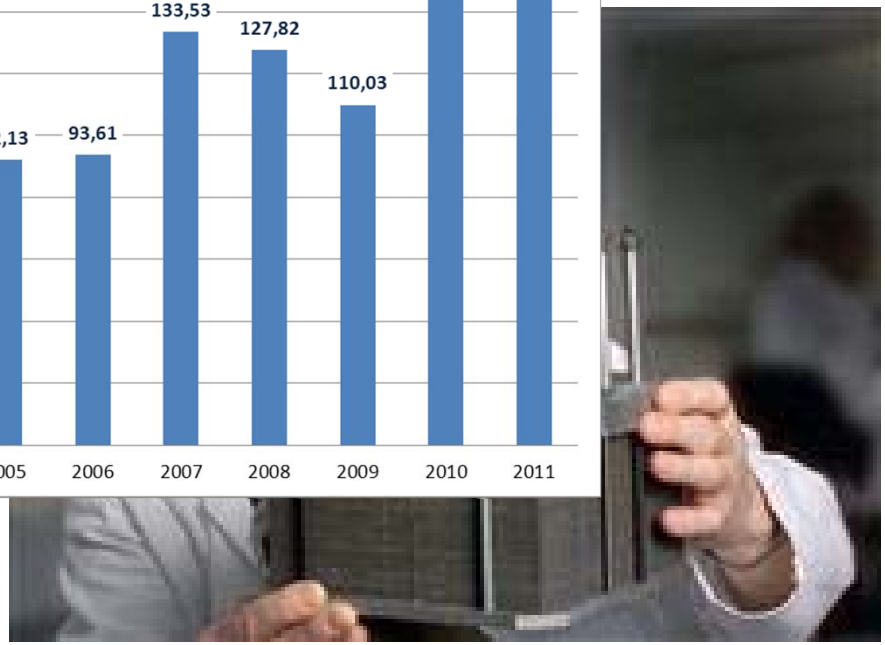
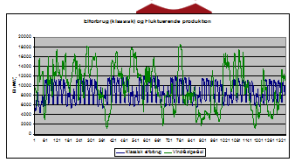
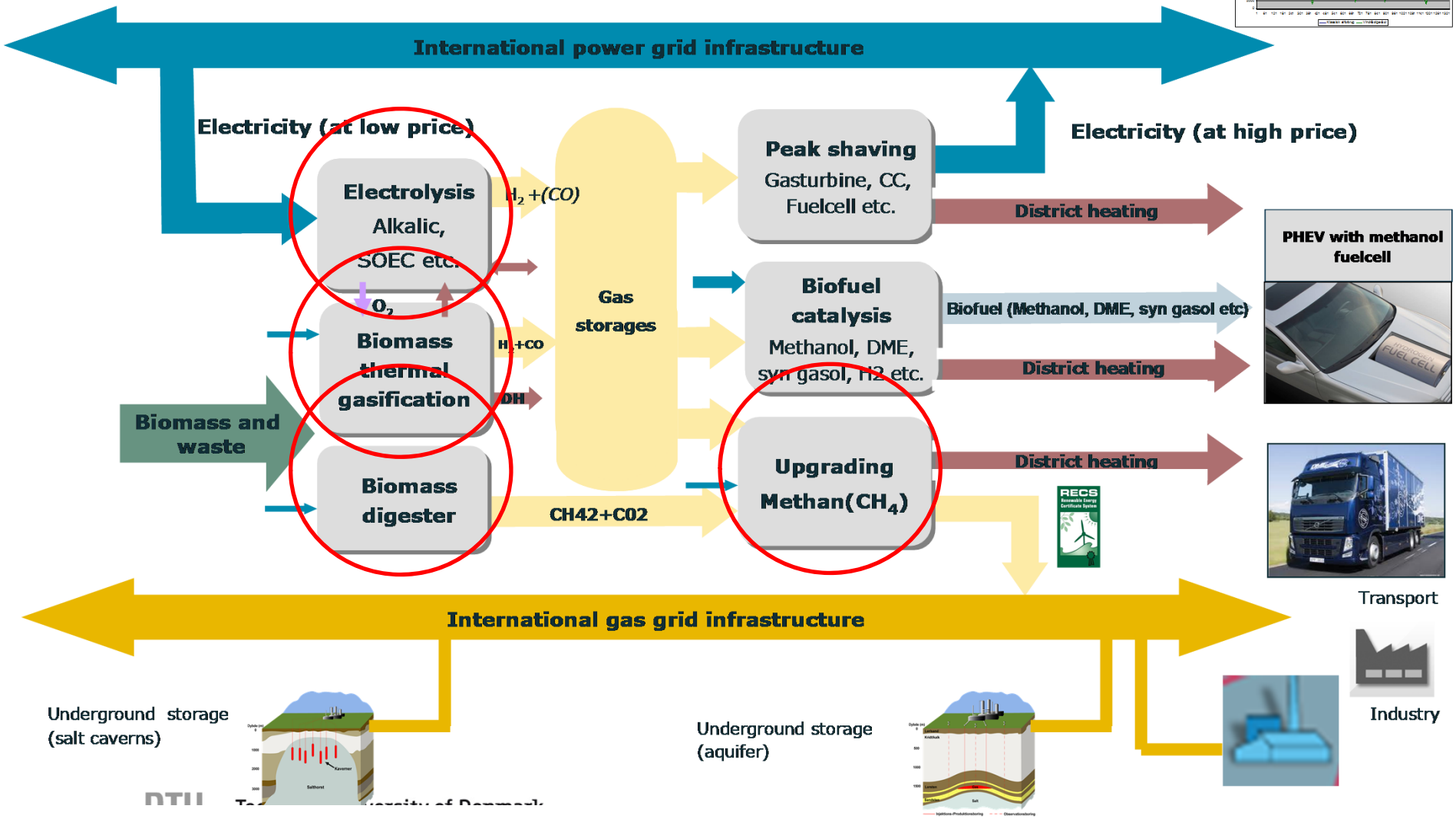


Photo: Poul Moeller, Topsoe

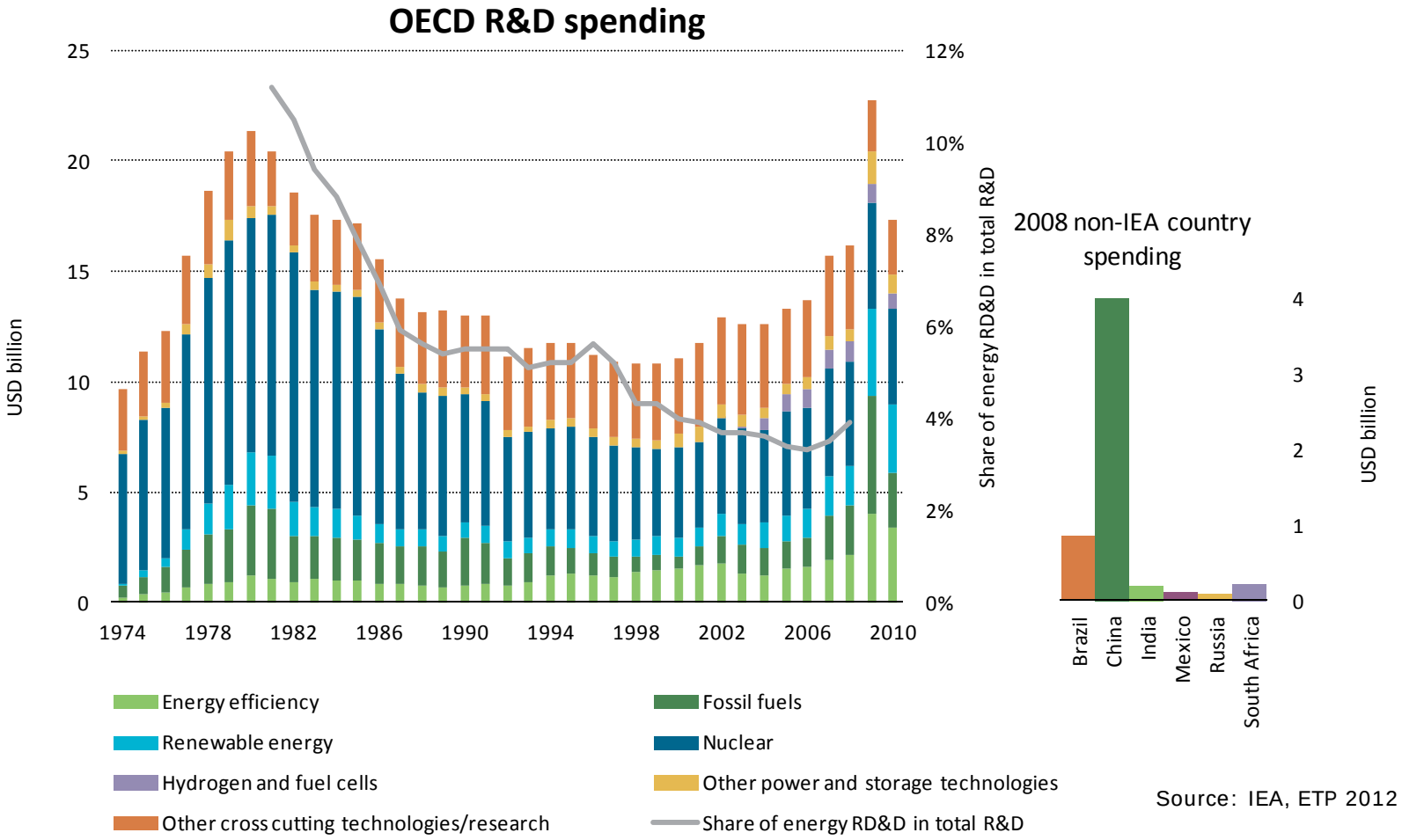
Integration of electricity, heat, gas and fuel-production





Source: Energinet.dk

Energy R&D in OECD



Source: IEA, ETP 2012

Conclusions

- **The energy system will change drastically over the next 30-40 years**
  - Wind power will dominate the energy system
  - Fewer power plants
- **New technologies are needed**
  - Smart grid, Flexible demand, Fuel cell electrolysis, Thermal gasification…
  - Complex interactions between power, gas, heat and transport……
- **Strategic Energy Research has an enormous role to play**
  - We should be careful in not trying to predict the technological future too much….